

Valuation of first-aid treatments efficacy in case of chemical burns

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The choice of first-aid treatments in case of eye or skin splashes always arouses many questions in the world of work. Three main questions come up currently :

- Is the traditional washing with water efficient for first-aid in case of splashes with chemical products ?
- Can another methods be efficient ?
- Should we privilege a more efficient technique ?

The appearance on the market of a new amphoteric solution¹ was the beginning of renewed interest about these questions and let to an investigation designed to know the effects of the different first-aid treatments used in case of chemical products splashes (essentially ocular).

This investigation, co-ordinated by the French National Institute for Research and Safety in collaboration with the company offering this buffer solution, was made by calling on the occupational doctors participation in 1988². The first results, concerning 73 observations, were published in 1993³. Since this first publication, the investigation was continued. If it is possible at present to give more acute data, we have to regret the too restricted amount of files. This still leads, for many statistical comparisons, to a lack of power that does not allow to give conclusions with certainty.

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¹ Diphotérine[®], PREVOR Company (the only product of this type marketed in France at present)

² First-aid treatments in case of chemical products splashes in the eye. *Documents pour le médecin du travail*, 1988, **36**, pp.439-441

³ FALCY M., BLOMET J. – First-aid treatments in case of eye splashes. First results of the investigation. *Documents pour le médecin du travail*, 1993, **53**, pp.33-41.

1. METHOD

This work is based on the analysis of a questionnaire that was at the occupational doctors' disposal. They could fill in on observations after each accident and send it the survey co-ordinators for data processing and analysis. This questionnaire was published on two occasions in the *Documents pour le médecin du travail* (^{2,3})

This way to proceed has several disadvantages and has several angles that have to be taken into account in the conclusions. So the fact that the patients were not examined by the same doctor can introduce the possibility of a discordance in the assessment of the symptoms and the files codes.

Despite its disadvantages, this method was chosen because it seems it was the only one suitable to take into account the multiplicity of these accident and work situations, as well as the first-aid treatments.

It was not possible to imagine a standard double-blind study with a test group, because each employed method needs different equipment, time and necessary volumes. It is ethical to replace products very well known for their efficacy with placebos ? How can we simulate a prolonged washing with water ?

The experimentation on animals gave some answers, but in very particular and standard circumstances that very rarely reflect a situation at work.

In order not to add new uncertainties in the files data processing, the codes and data capture were centralised and done by just one person.

Conventions adopted for the analysis

pH

When the pH was not precisely given, but simply a margin (0-1 or 12-13), the average is used (here 0.5 or 12.5) for the statistical analysis.

Sick leave

In one file, it was specified that the casualty had a sick leave, and its length was not noted. An eight days length was arbitrarily assigned to this observation.

Gathering by classes

For some heading, some gatherings were made to reduce the amount of classes and to improve the statistical analysis :

- for the pH, three classes were established :

$0 < \text{pH} \leq 1.5$;

$1.5 < \text{pH} \leq 10.5$;

$\text{pH} > 10.5$;

- for the age, the observations were divided up in five classes :

< 20 years old ;

$20 \leq \text{age} < 30$;

$30 \leq \text{age} < 40$;

$40 \leq \text{age} < 50$;

≥ 50 years old.

Treatments

Two files mentioned a treatment with Dacryosérum[®], they were included in the class of treatment with eye lotion. The files entailing a treatment with a sodium chloride solution were gathered with the treatments with isotonic solution.

Products

The products different from acids and alkalis were very varied. They were split up in two groups : the solvents and the “other products”.

The analysis concerning a quantitative variable are made by EPI INFO[®]. The analysis concerning a qualitative variable are made by the χ^2 study and possibly by the Yates method for small samples.

2. RESULTS

Descriptive analysis of the files

Amount of files

- 180 files were sent (including the 73 files analysed for the first publication) :
- 145 are complete and used for the statistical study ; there are 124 cases of splashes concerning either only the eye, or the eye and the face, and 21 cases of splashes on the skin, 2 of which on the face without any attack to the eye ;
 - 35 were collected on a form different from the proposed questionnaire. These files, incompletely documented were treated separately ; they are made up from 23 eye splashes, 6 mixed splashes, concerning the face and the eye, and 6 skin splashes.

Population studied

It is made up from 145 persons : 120 men (82.8%) and 25 women. The age is known in 124 files : it is 34.8 year old (± 10.4); there are no differences between the women (35 ± 10.9 year old) and the men (34.8 ± 10.4 year old) (fig. 1).

Dividing up of the files

The table 1 shows the dividing up of the files according to the nature of the product : we can note the domination of the splashes with acids or alkalis, without any difference in the frequency according to the sex.

The dividing up of the observations according to the pH shows a bimodal dividing up that indicates that we are frequently dealing with strong acids ($\text{pH} \leq 1.5$) or strong alkalis ($\text{pH} \geq 11.5$) (fig; 2).

Lastly, the splash concerns the eye in 95 cases (65.5% of the cases), it is mixed (skin and eye) in 29 cases (20%) and concerns only the skin in 21 cases (14.5%).

The analysis according to the sex does not show any difference for the kind of splashes, the gravity or the kind of washing carried out. The only difference that exists concerns the necessity of secondary care. It is not possible to know if this conveys a bigger gravity in case of accidents on the men or a negligence, particularly during the first-aid.

Skin splashes

50 files concern skin splashes : 21 affecting only the skin, 2 of which the face skin (without the eyes) and 29 the skin (face and other) and the eyes. In this last case, we can notice that the secondary care pointed out concern sometimes only the eye washing.

The 20 acid splashes (pH between 0.5 and 1.5) are essentially due to nitric sulphuric and hydrofluoric acid. However in 4 files, we can find a mixture of sulphuric and hydrofluoric acids.

The 15 accidents involving alkalis pH between 12 and 14 are essentially due to caustic soda or potash. Lastly, among the 15 accidents with varied products, we can find 6 ties organic solvents.

Most of these splashes develop simply, as 41 do not give any sick leave. But 21 (42%) need care and 9 a sick leave, 3 of which are the longest sick leaves from our series (skin and eye mixed up) :

- A 120 days sick leave, after a concentrated sulphuric acid splash on the thighs and the lower limbs. The length of the washing was short because of the cold temperature of the used water.
The subject had skin scars on the groin and psychic troubles possibly responsible for the unusual length of the sick leave;
- A 21 days sick leave, after a soda splash on the hand, on a grafted area. The washing with water lasted around 3 minutes. The subject, 72 hours after the accident, gets to note a burn needing secondary care;
- A 18 days sick leave, after a nitric acid splash in the eyes and on the face, an arm and a foot.
A 15 minutes shower with water was started immediately, first with a little shower then a shower. The effects will be simple for the eye, but after 18 days of care and sick leave, there will still be light scars on the face.

It is important to stress that these three observations follow a bad or insufficient washing with water : either the length is too short because of the temperature, or prematurely stopped without any reason, or insufficient because of a concomitant eye splash that has possibly summoned all the care.

Globally, we can see, as shown by the diagram 3, that only the acids and the alkalis give burns or serious burns. The two products pointed out “mixing “ contain phenol, a solvent and an alkali; it is so not astonishing that they can induce a serious skin burn.

If we note that the bad or notable burns happen in the groups with or without treatment with water (fig. 4) and less in the group treated with Diphotérine®, it is however not possible to conclude statistically that a method is better than the others. This can be linked to a lack of power due to the low amount of observations.

Skin splashes

Analysis method

We were more particularly interested in showing differences between the consequences of the accidents according to the kind of washing used. The analysis were done each time by taking into account the nature of the product (acid, alkali, or others).

Three elements allow to appreciate the consequences for the eye : the symptomatology, the possible sick leave and the necessity of secondary care.

Symptomatology

It is always precisely described in the files. In order to do the statistical comparisons, two methods were retained :

- The first one is based on conveying of the symptomatology in an arbitrary factor intended to allow quantitative analysis :

No symptom = 0 ;
Blepharitis = 1 ;
Conjunctivitis = 2 ;
Keratitis = 3 ;
Choroiditis or uveitis = 4.

When several symptoms are noted on the same subject, the global factor is equal to the sum of each sign's factor (for example, blepharo-conjunctivitis : factor $1+2 = 3$). This factor does not have any absolute value significance, but it is quite adequate to show the gravity of the effects. However it has the disadvantage of overestimate some symptoms like blepharitis or conjunctivitis that generally give no consequences : this localised inflammation is just the testimony of a normal defence reaction of the organism against a chemical aggression. It is true that in this case a keratitis has the same gravity as the one of a blepharo-conjunctivitis;

- The second one is aimed at controlling if the use of this arbitrary factor had modified the statistical results. In this case the analysis was made after dividing up of the observations in two groups according to the symptomatology :

Group 1 : no effects, blepharitis or conjunctivitis ;

Group 2 : keratitis, choroiditis, uveitis.

The results of this qualitative analysis are not different from the ones using the previously described variable. In order not to weigh down the text, these results will not all be detailed.

Sick leave

The analysis was made taking into account the amount of days lost from work (this variable can be very subjective and an accident with a big amount of days lost from work, can strongly influence the average), but also by taking into account the amount of accident needing a sick leave.

Secondary care

It is the last element taken into account whatever the length of these care is.

Acids

The series contain 38 observations : 6 women with an average age of $37.5 (\pm 7.5)$ and 32 men with an average age of $31.45 (\pm 9.87)$.

In 25 observations, the pH of the product was below or equal to 1.5.

There is, in this series, a correlation between the gravity factor and the length of the sick leaves (table III), as well as the frequency of secondary care (table IV). This seems indicate that the observations were reported in a consistent way and that the use of an arbitrary factor does not modify the results. The average gravity factor is 2.5.

We can notice that 18 files concern splashes involving hydrofluoric acid (HF), either alone, or mixed. 12 subjects were first washed with Diphotérine®, 3 with water, 2 with a mixture water + Diphotérine® and 1 was not washed in the first 3 minutes. There is a high rate of cases washed with Diphotérine®; we have to take this into account in our interpretation of the results because the product is not considered as efficient on hydrofluoric acid splashes.

Yet, there were no serious consequences or after-effects in any of the cases. This shows, either that the quantities splashed were low, or that the care were quick and efficient. Taking into account the danger of hydrofluoric acid, it is likely that the person working with it are aware of it and react quickly in the event of an accident.

We do not observe any effects in 14 observations and a keratitis in 10 cases (6 of which involving hydrofluoric acid) (fig.5).

The statistical analysis does not allow highlight a difference in the gravity neither according to the king of primary washing carried out (fig. 6), nor according to the kind of complete washing carried out (primary + secondary washing). There is either no difference concerning the amount of days lost from work or the amount of cases needing secondary care (Table V).

Even if the amount of observations is too low to allow a statistical conclusion, we can wonder why the best score is reached when there is not any washing. We can wonder if in these 5 cases, the projection was considered straightaway as of minor importance by the injured, and then not washed.

We can also notice that, even if the immediate gravity is similar according to the washing methods, the amount of days lost from work is very low in the observations treated first with Diphotérine®, even if this result is not statistically significant. The comparison of the standard deviations (5.11 for water and 1.7 for Diphotérine®) shows moreover a more constant action of the active product in these cases.

Alkalis

55 observations of accidents involving an alkali : it is about 9 women and 46 men. The average size is 36.78 ($\pm$ 9.30) years old for the women and 39.98 ($\pm$ 9.45) for the men (p=NS).

In only 4 observations the pH of the product is lower than 12.

We can notice that the seriousness of the splashes is more important than the one of the acids, which confirms a know fact (table VI).

There were no serious consequences at the end, nor after-effects in any of the reported cases.

Like for the acids, there is a significant relation between the gravity average and the necessity of a sick leave (table VII), or of secondary care (table VIII).

The consequences of the accidents with alkalis are represented on diagrams 7 and 8. Even without reaching threshold of statistical signification, we can notice that the percentage of low ocular attack (nothing or blepharitis) is important in case of a washing with Diphotérine® : 31.25% of the cases, when they only represent 7.70% of the cases when no washing was carried out and 4.76% when a washing with water was carried out.

There is either no significant statistical difference between the primary washing method and the seriousness of the attack or the necessity to have a sick leave or secondary care.

We can notice, like for the acid splashes, that the amount of days lost from work is the lowest when Diphotérine® is used as first, without any change in the initial gravity (table IX).

The analysis according to the gravity groups is shown in the table X. The files entailing a washing with water + Diphotérine® and the ones washed with an isotonic solution were included in the group of the files washed with water. We checked that this choice did not have any consequences on the result of the statistical test.

Other products

It is about 31 files concerning 5 women and 26 men; the average age is 20.25 ± 3.10 years old for the women and 33.22 ± 9.57 years old for the men ($p < 0.05$).

13 observations concern the solvents and 18 varied substances (table XI). We do not notice a difference in the gravity according to this criterion.

Only two accidents needed a sick leave, but 21 of them were followed by more or less prolonged care. No after-effects were reported.

Either the immediate washing was made with water, or no washing was carried out. In all cases, the consequences were minimal, 4 keratitis cases amongst the 31 observations (fig.9).

We can not notice any difference in the development of the damage according to the kind of washing used.

Incompletely documented files

There is 35 files like that : 23 concern a pure eye splash, 6 a mixed splash; on the eye and the skin, and 6 a splash on the skin only. Many information are missing, and does not allow to analyse the results. In particular, the symptomatology is not precise enough, as well as the effects (secondary care and sick leave). However, it is sure that no after-effect was observed after these accidents.

Concerning the symptomatology, the term “light burn” seems to have been employed when an attack of the eyelid was noted, a “burn” corresponds to an attack of the conjunctiva and a “serious burn” to a corneal attack.

Only one serious eye burn was noted after a splash with caustic soda and a washing with water. The skin attacks stay always mild.

3. DISCUSSION

We have to note straightaway that the amount of observations is low, and in some cases does not allow to reach the necessary statistical power. The whole observations collected can certainly not be appreciated as representative of all the situations and products used in the industry or the arts and crafts. Therefore the results have to be considered as simple tendencies.

The absence of any serious accident with after-effects is the first surprising element. Shall we conclude that the splashes with chemical products in the eye always have an happy end ? It is more reasonable to suppose that due to the way of collection based on a voluntary action, the grave accidents were not reported.

We can in particular notice that even splashes with hydrofluoric acid did not entail irreversible consequences. It is likely that in the workshops using such a substance, the persons are warned of the danger and then the rinsing is very quick. In fact, the efficacy of the eye washing is linked to the rapidity of the intervention and its length : we have to notice that the longest sick leaves followed skin splashes insufficiently rinsed.

It is then confirmed that the basic products have a bigger gravity on the eye than the acids, and all the more so the solvents and other substances. With the alkalis, the asymptomatic cases are rare.

Concerning the treatment, despite some obvious differences, it is not possible with this study to conclude statistically that a method is better than the others. We have to stress the importance of the training of the first-aiders, who have to be aware of the advocated technics. In particular it is important to precise the necessity of a water rinsing with a sufficient length (at least 15 minutes), with the eye open. We note that this requirement is not always easy to obtain, especially when the liquid does not have an optimal temperature. It is obvious that in several files the use of too cold water interrupted prematurely the treatment and induce a tendency to close the eye; it can even be bad tolerated in a general manner (hypothermia) requirement has to be taken into account in the decision to install first-aid equipment. The use of the complete dose of Diphotérine®, according to the manufacturer's recommendations is also important : in some cases, as the eye pain decreased rapidly at the beginning of the washing, it was interrupted too quickly, and that limited the efficacy of the method.

The mixed methods of treatment does not show any benefit, whatever the order of application of the products is (water then active substance, active substance then water). The care risk to be more complicated to apply, so these methods can not be recommended.

Lastly, we can confirm a tendency already reported at the time of the publication of the first results in 1993 : the amount of days lost from work is less important after treatment with Diphotérine®, when the gravity factor is not modified. This tendency was confirmed in several companies, by other enquiries not published at present.

CONCLUSION

The relative mildness of the observed cases in this investigation does not allow to forget the large number of days lost from work and the necessary care to treat the splashes of these chemical products. It seems important to stress that even if the first-aid treatment methods proved to be globally satisfying, the priority should still be the primary prevention of these accidents (collective and individual protections).

Even if it is possible to know its exact reason, the first lesson of this investigation is the general efficacy of the methods used (water, isotonic solution, Diphotérine®) without the possibility to privilege one, probably because of the lack of statistical power.

This efficacy depends on the rapidity of the first-aid. This imperative can be an element for the choice in some cases (isolated or itinerant work). The other element to take into account is the comfort of use (in particular thermal), which must allow a prolonged washing without inducing local pain or hypothermia.

It seems also important to emphasise the fact that the first-aiders must be trained to the chosen method to be efficient, to know exactly its mode of application. Any change in the method, decided by the company, advised by the occupational doctor, will then have to lead to a training.

If the results do not put a significant statistical difference between the different treatments to the fore, it would however be interesting that complementary studies could confirm the tendency to a reduction of the sick leaves and the necessary secondary care in case of splashes treated with Diphotérine®.

Despite the constant number of questions on this subject, the realisation of such an investigation proved to be particularly difficult, because it only motivated a restricted number of occupational doctors. The time necessary to gather a sufficient number of data is too long for this methodology to be reused.